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RESEARCH DEPARTMENT

REPORT

A camera tube lag meter

No. 1969/43

Research Department, Engineering Division
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M.J. Mortimore, B.Sc.
I.D. Chisholm, B.Sc.

D. Maurice

Head of Research Department

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A CAMERA TUBE LAG METER

SUMMARY

The exposure of a camera tube to a brief flash of light and the measurement of the magnitude of the signal current after a known number of television fields can provide an indication of the speed of response of the tube to changing light levels. A meter which permits accurate measurements, in the presence of noise, to within an accuracy of $\pm 0.1\%$ of white level is described and its performance is discussed.

1. INTRODUCTION

Lag in a photoconductive camera tube results from inherent delays in the response of the photoconductive target material to changing light levels (photoconductive lag), and from incomplete discharge of the target by the beam during any one scan (capacitive lag).

With the now widespread use of photoconductive tubes, an accurate and rapid method of measuring overall lag characteristics is required. This is of special importance in the case of tubes used in colour cameras, since abnormal lag characteristics are one cause of coloured trailing on moving objects.

2. GENERAL

The technique adopted uses a pulsed light source which is arranged to illuminate a small area of the tube target, the remaining area being in darkness.

The light source can be switched on and off at regular intervals so that the speed of response to the application and removal of light can be measured. Two types of measurement are possible. The first is a measure of the speed of response of the tube when illumination is applied after a period of darkness, and is often referred to as 'build-up lag'. The second is the speed of response to the removal of illumination; this is often described as 'decay lag'.

During any single television field throughout the on/off cycle of the light source, samples may be taken of the magnitude of the video output from the tube. The samples correspond to two areas of the picture, one dark, and the other illuminated. By measuring the difference between these samples the magnitude of the tube output can be obtained, the value being independent of the black-level

setting. The way in which the tube output builds up ('build-up lag') may be investigated by sampling after the light source has been turned on; 'decay lag' may be measured by sampling after the light source has been turned off. Any field during the light source cycle may be selected for sampling so that it is possible to examine, field by field, the response of the tube.

Samples of the tube output taken at the same point in every light source cycle will all be of identical magnitude apart from added noise. These successive samples are averaged in a circuit with a long time constant so that the final measurement is almost independent of noise level.

The two areas of the picture to be sampled are defined by two internally generated 'white pulse' waveforms and, in order that one of these areas may be aligned with the illuminated area of the target, both waveforms and the tube video signal are fed to a picture monitor; the areas being sampled then appear as white rectangles (or windows) superimposed on the camera output. Typical positions of these 'windows' relative to the area of illumination are shown in Fig. 1.

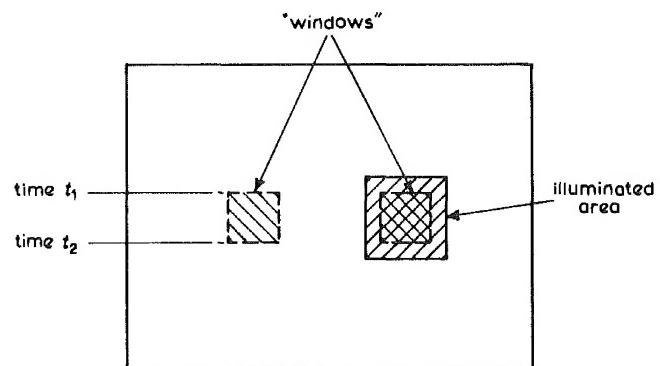


Fig. 1 - The positions of sampling 'windows'

The duration of the light pulse may be adjusted between the limits of 1 and 256 fields and the period for which the light remains off between 64 and 1024 fields. The precise times at which the illumination is switched on and off is controlled by the 'window' waveforms. For decay-lag measurements the light source is switched off at time t_1 , shown in Figs. 1 and 2(a); if, for example 'FIELD 1' is to be measured, sampling starts immediately and ceases at time t_2 , but if 'FIELD 3' is selected, sampling still occurs between times equivalent to t_1 and t_2 but exactly two fields later.

In the case of build-up lag measurements, the illumination is switched on at time t_2 and sampling again takes place between times t_1 and t_2 (Fig. 2(b)) on whichever of the ensuing fields is selected.

3. CIRCUIT DESCRIPTION

The illumination is provided by an unscanned short persistence cathode-ray tube which can be switched rapidly on and off. The timing of the light source is controlled by a binary counter which is reset when the light is switched on (or off) and starts counting the required number of fields before again switching the light off (or on).

The outputs of the counter stages are also taken through an array of switches to an AND gate so that a pulse coincident with any one selected field may be obtained by setting the appropriate binary number on these switches. This selected field pulse is used to generate the sampling pulses and occurs during the light source 'on' period for build-up lag measurements and during the light source 'off' period for decay-lag measurements.

The two tube output samples that are taken during the selected field are both stored capacitively and fed to a d.c. difference amplifier, so that a d.c. output representing the residual tube output is available for display by means of a digital voltmeter.

When measuring decay lag the tube output level in the sampling period immediately following the removal of the illumination is taken as the 100% reference. The output level of the d.c. amplifier, therefore, is adjusted so that a convenient voltage (e.g. 1 volt) is displayed when this sampling period is selected. The magnitudes of samples taken later in the light-source cycle can then be directly read off as percentages of this reference level.

When build-up lag is measured, the reference level is taken as the magnitude to which the tube output rises if exposed to illumination for a long time (say 50 fields).

4. PERFORMANCE

4.1. Linearity

The linearity of the device was tested by measuring the difference between two points on a step wedge waveform as the input was progressively attenuated. Readings in the range 1 to 10% of white level were accurate to $\pm 0.1\%$ of white level.

4.2. Common Mode Rejection

Since the device operates by measuring the difference between two samples, its output should in theory be independent of input black level. In practice, the common mode rejection is about 100 : 1.

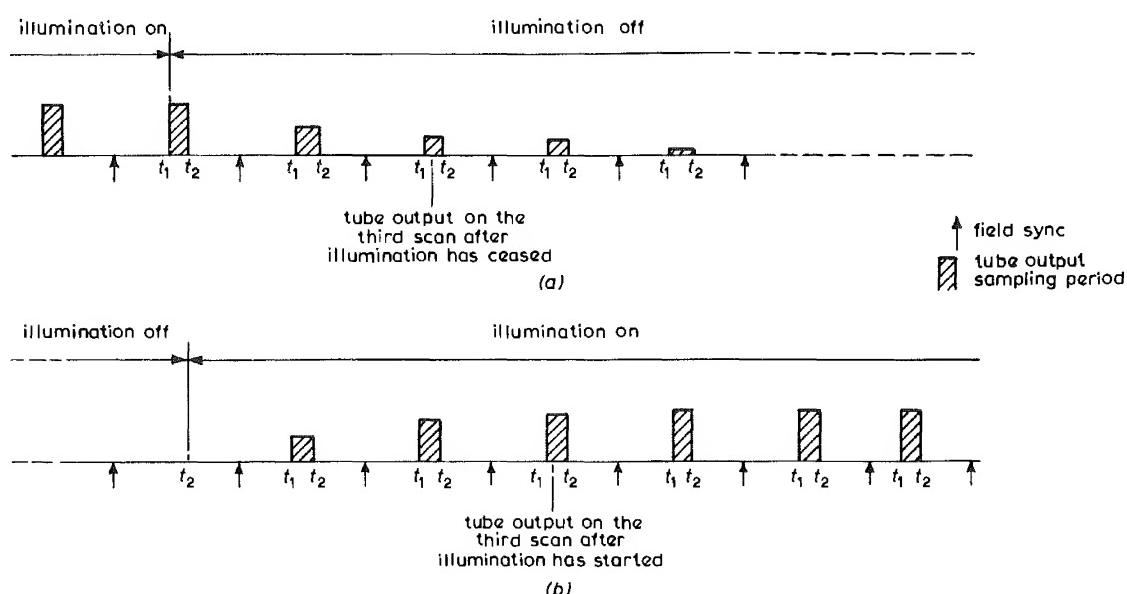


Fig. 2 - Relative timing of illumination and measurement
(a) Decay lag (b) Build-up lag

4.3 Noise

The sample and hold circuits are insensitive to noise as a result of the averaging effect of the storage capacitors, but excessive noise could affect the video clamp circuit, and hence the video black level. The addition of white noise at -20 dB r.m.s. relative to the signal level corresponding to white causes variations in the output of not more than 0.1% of white signal.

4.4. D.C. Drift

With no video input, the d.c. drift of the zero setting is about 0.1% of white signal. This results from slight changes in the voltage offsets across the field effect transistors used in the d.c. stages.

4.5. Other Disturbances

The presence on the video input of any disturbance which has a frequency of the same order as the line rate will

cause variations in the output, and the voltmeter reading will not stabilize.

5. CONCLUSIONS

The meter enables lag in camera tubes to be measured to an accuracy of $\pm 0.1\%$ of white signal in the presence of noise. The main advantage of the technique adopted is the unambiguous indication of lag, without the uncertainty that is introduced when small signals are examined on an oscilloscope in the presence of noise.

Accuracy is mainly limited by the stability of the d.c. amplifier; if greater accuracy were required, this could be achieved by a more complicated amplifier design.

